Check List the journal of biodiversity data

NOTES ON GEOGRAPHIC DISTRIBUTION

Check List 12(2): 1855, 14 March 2016 doi: http://dx.doi.org/10.15560/12.2.1855
ISSN 1809-127X © 2016 Check List and Authors

New records of the William's Jerboa, *Paralactaga* cf. *williamsi* (Thomas, 1897) (Rodentia: Dipodidae) from northeastern Iran with notes on its ecology

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Abstract: *Paralactaga williamsi*, a five-toed jerboa, is known to occur in Anatolian Turkey, northern Lebanon, Armenia, Azerbaijan and western Iran. Here, we report the first record of this species in Kopet-Dag Mountains, northeastern Iran. Species identification was based on external morphology, skull and molar teeth morphology and morphometrics studies, as well as molecular analyses. Brief notes on the ecology of the species are also provided. This new record expands the distribution of *P. williamsi* in Iran about 850 km eastward, however further sampling will be needed for a better judgment on the taxonomic status of this species in eastern Iran and to determine the patterns of its distribution. Since the specimen did not group with other *P. williamsi* in the cytochrome *b* analysis, we provisionally classify the specimens as *P.* cf. *williamsi*.

Key words: five-toed jerboa; eastern Iran; range extension; new record; habitat

The five-toed jerboas of genus *Allactaga* Cuvier, 1837 (*sensu lato*) traditionally included 12 morphospecies distributed in the arid and semiarid of North Africa, Iranian plateau, to central Asia and Mongolia (Lay 1967). Five species of this group, now classified in the genus *Paralactaga*, Young, 1927 (Lebedev et al. 2013), are reported from various regions of Iran, including: Small Five-toed Jerboa (*P. elater* Gray, 1824), William's Jerboa (*P. williamsi* Thomas, 1897), Euphrates Jerboa (*P. euphratica* Thomas, 1881), Hotson's Jerboa (*P. hotsoni* Thomas, 1920), and Toussi Jerboa (*P. toussi* Darvish, Hajjar, Matin, Haddad and Akbary rad, 2008) (Lay 1967; Darvish et al. 2008; Tarahomi et al. 2010).

Allactaga williamsi was described from Lake Van, eastern Turkey. Its distribution range extends through Anatolia, the Caucasus (Armenia, Azerbaijan, Iran), and northwestern Iran, with an isolated population in northern Lebanon (Colak et al. 1994; Wilson and Reeder 2005; Shenbrot et al. 2008; Kryštufek et al. 2013). In Iran, it has been reported from west and northwestern parts. Lay (1967) reported William's Jerboa for Qazvin, Azarbaijan, Kordestan, Lurestan, Hamedan, Tehran, and Zanjan and Tarahomi et al. (2010) reported it from Ardabil, Ilam, Hamedan, Zanjan, Tehran and Chaharmahal-o-Bakhtiari. It ranges from 23 m below sea level in Azarbaijan to 2,355 m above sea level in northeastern Turkey. William's Jerboa occurs in steppe regions with sparse vegetation. In Turkey, it is rarely found in cultivated lands, although it occurs in secondary steppe habitats where natural vegetation remains (Çolak and Yiğit 1998). In Azerbaijan, the species is considered common in semi-desert, foothills and mountain steppes and rare in lowland and riparian forests (Lobachev et al. 1976; Shenbrot et al. 2008).

In this study, we report the occurrence of *P.* cf. *williamsi* in the northeastern regions of Iran, based on two specimens captured in Kopet-Dag Mountains of Iran. We also provide dental and cranial measurements, phylogenetic tree and brief notes on the ecology of this species.

The study was conducted in April 2015 in Kopet-Dag Mountains, northeastern Iran (36°56′02″ N, 059°31′12″ E; Figure 1). During field work two adult five-toed Jerboa females of genus *Paralactaga,* were followed using a flashlight and a car headlight in the night and were captured by hand.

Specimens were transferred to the laboratory and standard external measurement and weights of them were recorded. Cranial and dental measurements

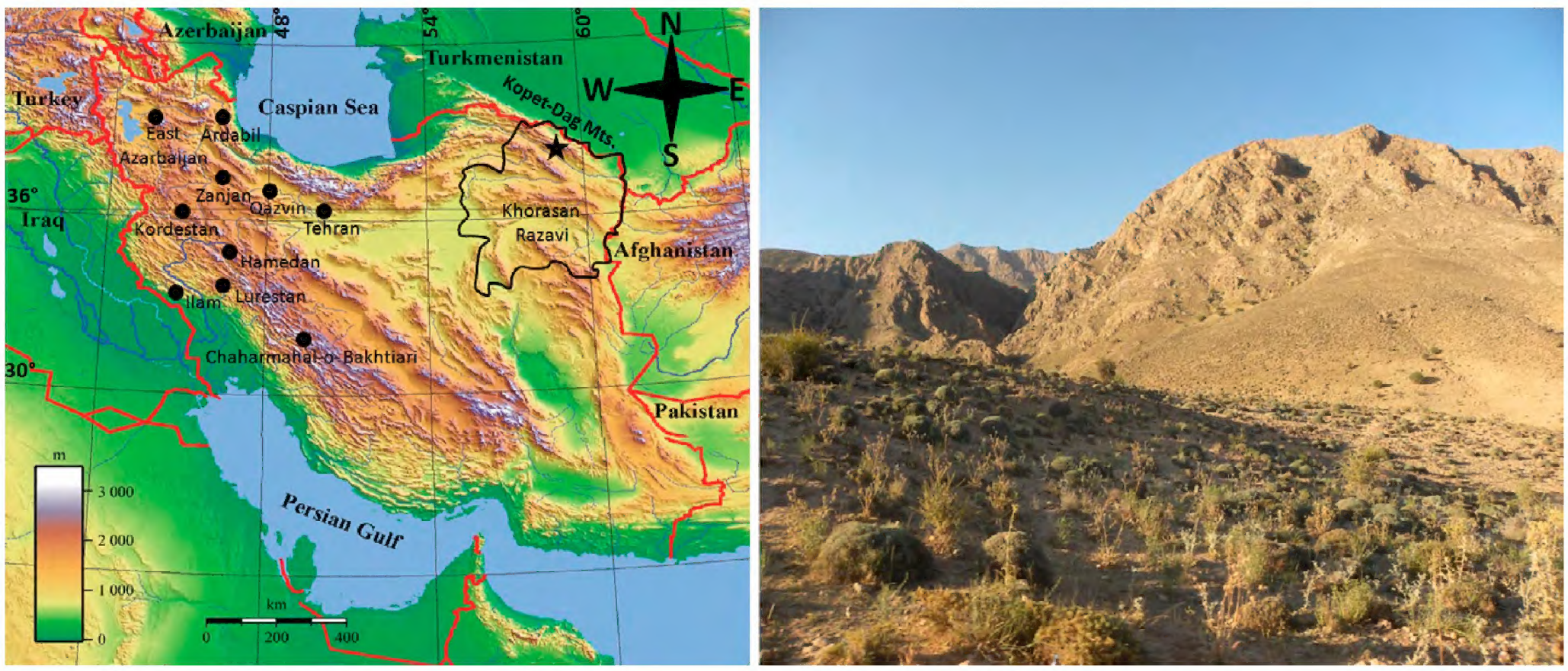

Figure 1. Sampling locality in Kalat county, Khorasan Razavi Province, northeastern Iran where two adult female specimens of *Paralactaga* cf. *williamsi* were collected. Black star and the black circles refer to the sampling locality (new record) and all previous records of occurrence of the species in Iran, respectively (left). Habitat and vegetation cover of the collecting locality (right).

were taken by digital caliper with 0.01 mm accuracy. Identification was based on external morphology, dental and cranial characters. Morphological characters of skull and teeth were studied under a stereomicroscope. Images were captured using digital camera (DP71) connected to stereoscope (Olympus SZH10). Skulls and mandibles were cleaned with papain powder (Sigma-Aldrich; P4762). Furthermore the skeletons (with skin) were fixed in 10% neutral buffered formalin (Merck Millipore; 103999). The material was deposited in the Research Group of Rodentology, Institute of Applied Zoology, Ferdowsi University of Mashhad, Mashhad, Iran with catalog numbers ZMFUM-5028 and ZMFUM-5029.

DNA was extracted and purified from 95% ethanol preserved muscle tissue by a modification of the methods of Bruford et al. (1992). The complete mitochondrial cytochrome *b* (*Cytb*) gene was amplified via the polymerase chain reaction (PCR) with the use of modified universal primers L7 (5′-ACTAATGACATGAAAAATCATCGTT-3′) and H6 (5′-TCTTCATTTTTGGTTTACAAGAC-3′) (Montgelard et al. 2002). The PCR protocol for tissue samples is described in Norris et al. (2008).

A total of 30 sequences representing eight *Paralactaga* species were analyzed for variations in the *Cytb* gene. Their GenBank accession numbers are given in Table 1. Furthermore, the nucleotide sequence (1355 bp) of one of our new reported samples, which is deposited in the ZMFUM nucleotide sequence databases with accession numbers ZMFUM-5028, was included in this analysis. Two sequences of lesser Egyptian Jerboa, *Jaculus jaculus* (Linnaeus, 1758), were used as outgroups.

Table 1. Cytochrome *b* sequences of *Paralactaga* and *Jaculus* species retrieved from GenBank.

Species	Accession number
Paralactaga balikunica	KM397180.1
Paralactaga bullata	KM397179.1
Paralactaga elater	JQ954934.1
	JQ954935.1
	JQ954936.1
Paralactaga euphratica	KC465442.1
	KC465443.1
	KC465446.1
	KC465448.1
	KC465449.1
Paralactaga hotsoni	JQ954939.1
	JQ954940.1
	JQ954941.1
	JQ954942.1
	JQ954943.1
	JQ954960.1
Paralactaga sibirica	JX891483.1
	JX891484.1
	JX891485.1
	JX891487.1
	JX891488.1
Paralactaga toussi	JQ954933.1
	JQ954938.1
	JQ954958.1
	JQ954959.1
Paralactaga williamsi	KC465439.1
	KC465440.1
	JQ954944.1
	JQ954947.1
	JQ954949.1
Jaculus jaculus	JN214539
	JX885200.1
Total	32

Figure 2. Dorsal body view of the *Paralactaga* cf. *williamsi* (ZMFUM-5028) from Kopet-Dag Mountains, northeastern Iran.

Nucleotide sequences were manually aligned and edited by eye using BioEdit (Hall 1999) for resolving ambiguous bases, and then were checked for gaps or stop codons in Mega5 (Tamura et al. 2011). Bayesian trees were constructed with MrBayes 3.1.1 (Ronquist and Huelsenbeck 2003) using Markov chain Monte Carlo (MCMC) methods. We conducted Bayesian phylogenetic analyses using the GTR + gamma + propinv model with unequal base frequencies. The robustness of the nodes was evaluated using posterior probabilities (PP), which PP 95% were considered significant for each branch in Bayesian trees (Leache and Reeder 2002).

The following external traits were observed: color of dorsal coat light brown, with hairs at the bases and apexes dark; ventral coloration is light cream, with hairs at the apexes dark; subterminal portion of the tail brush dark cream; inner surface of ear dark and with short brownish hairs at the tip; outer surface of ear dark with lighter margins and short brownish hairs; hind soles are completely naked and their margins are with short dark hairs; nails have dark bases (Figure 2).

Recorded body masses were 89 and 101 g; head and body length are 139 and 141 mm; total tail and tail brush length are 217 and 223 mm, and 83 and 87 mm, respectively; hind foot length are 59 and 61 mm; ear length are 49 and 51 mm and vibrissae length are about 73 and 77 mm. The external morphology and measurements are within the reported range for *P. williamsi* (see e.g., Darvish et al. 2008; Shenbrot et al. 2008; Toyran and Albayrak 2009).

The skull is characterized by a short and partly broad rostrum, and tympanic bullae that are inflated ventrally. The incisive foramina are large, the palatal foramina nearly oval and is small relative to the skull size, and the palate is broad. All molars have relatively small crown height and the third upper molar has complicated pattern, which is typical for the species of *euphratica* group. First and second upper molars are similar in appearance (Figure 3). The cranial and dental measurements are shown in Table 2; these measurements are within the range of *P. williamsi* (see e.g., Darvish et al. 2008; Shenbrot 2009; Toyran and Albayrak 2009).

Based on the Bayesian phylogenetic analysis (Figure 4), the *Paralactaga* sp. specimen from Kopet-Dag Mountains was the sister group of the clade *P. williamsi* + *P. euphratica* and the whole clade has a posterior probability of 52% in Bayesian tree.

The altitude of the sampling locality is approximately 2,251 m above sea level. The topography is barren high plains, with mounds and rocky habitats. The vegetation on this region is mostly *Acanthophyllum glandulosum* Bunge ex Boiss. (Caryophyllaceae), *Silybum marianum* (L.) Gaertner (Asteraceae), *Peganum harmalum* (L.) St.-Lag.

Table 2. Cranial and dental measurements (mm) of the two captured adult female specimens (ZMFUM-5028 and ZMFUM-5029) of *Paralactaga* cf. *williamsi*.

Variable	ZMFUM-5028 (mm)	ZMFUM-5029 (mm)
Condylobasal length	31.42	31.58
Zygomatic breadth	17.29	17.39
Length of tympanic bullae	8.53	8.89
Interorbital constriction	8.64	8.76
Length of diastema	10.24	10.66
Length of incisive foramina	6.77	6.86
Length of upper cheek teeth	6.54	6.80
M1 length	2.12	2.52
M1 width	1.83	1.97
M2 length	1.75	1.99
M2 width	1.33	1.65
M3 length	1.27	1.51
M3 width	1.29	1.53
Length of mandible	19.01	19.17
Length of lower cheek teeth	6.88	6.90
m1 length	2.34	2.56
m1 width	1.40	1.74
m2 length	1.98	2.02
m2 width	1.93	2.17
m3 length	1.94	2.02
m3 width	1.39	1.63

Figure 3. Skull (lateral view), mandible (lingual view) and left tooth row (right: upper and left: lower) of the *Paralactaga* cf. *williamsi* (ZMFUM-5028) from Kopet-Dag Mountains, northeastern Iran.

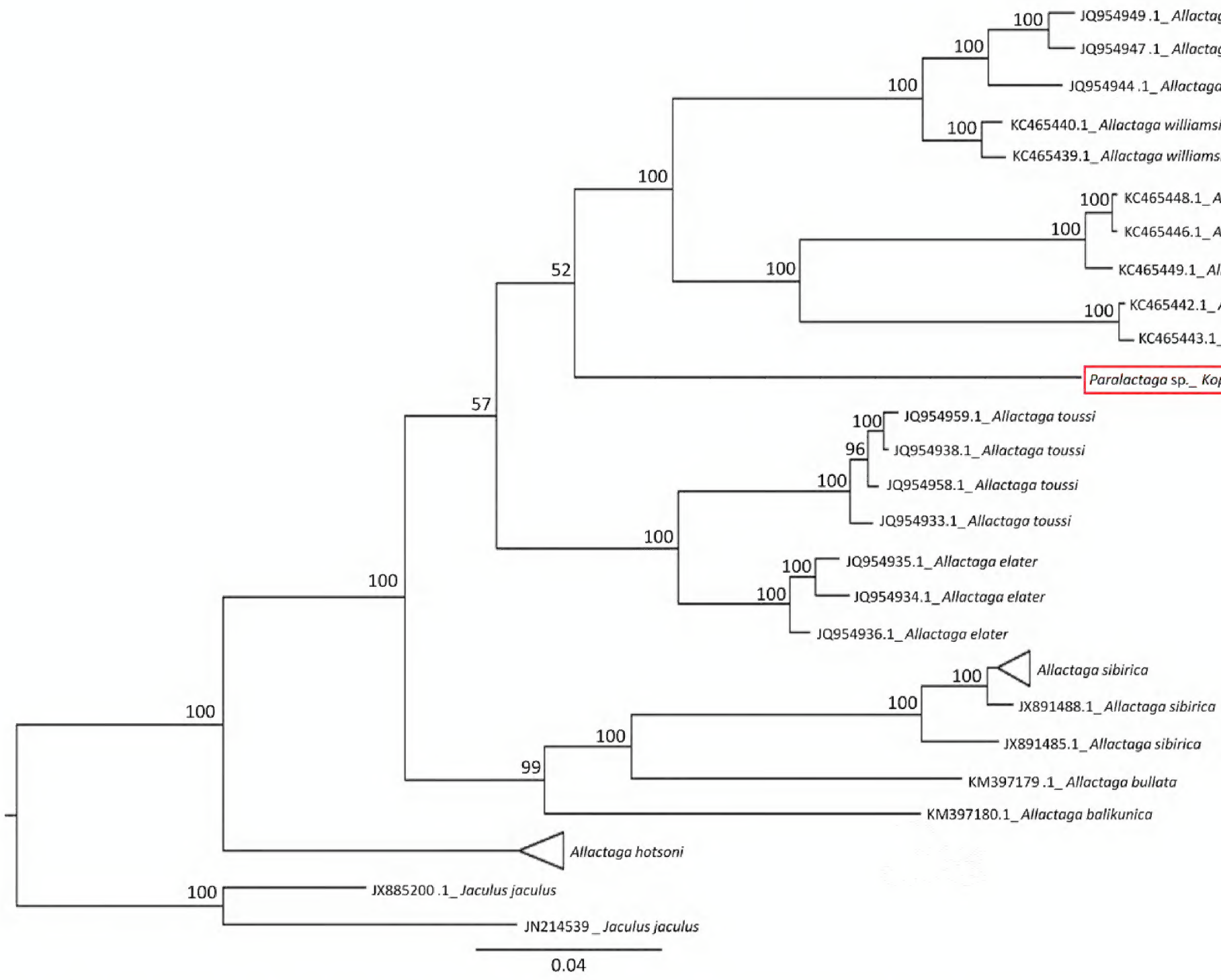

Figure 4. Bayesian tree resulted from the Bayesian analysis of cytochrome *b* for 31 *Paralactaga* species rooted with two *Jaculus* species. Numbers above branches represent posterior probability values.

(Zygophyllaceae), and with sparse cover of *Reseda lutea* L. (Resedaceae), *Verbascum thapsus* L. (Scrophulariaceae), *Aegopordon* sp. Boiss. (Asteraceae), *Juniperus excels* M. Bieb. (Cupressaceae), *Rosa canina* L. (Rosaceae) and *Berberis integerrima* K. Koch (Berberidaceae) (identified in Plant Biodiversity Research Lab, Ferdowsi University of Mashhad). Habitat and vegetation cover are shown in Figure 1. Animals were observed to live in the areas having firm soil. In the research area, other Glires such as *Calomyscus* sp., *Cricetulus migratorius*, *Meriones persicus*, *Mus musculus* and *Ochotona rufescens* (Lagomorpha), were recorded.

Parallactaga williamsi has been reported in western and northwestern Iran (Wilson and Reeder 2005) and it is limited to Zagros and northwest mountains of Elburz (Darvish et al. 2008; Tarahomi et al. 2010). Lay (1967) and Tarahomi et al. (2010) reported the easternmost point of the presence of this species in Iran for Tehran and Chaharmahal-o-Bakhtiari (Dasht-e-Marjan), respectively. Furthermore, there is a specimen in collection of the Field Museum of Natural History (Chicago) which was collected in Qazvin, Rachtagan — the point which is most close to our site. We extend the boundary of this species' distribution about 850 km eastwards, up to Kalat county (Kopet-Dag Mountains), in the northeastern Iran. The *Cytb* usually performs well for inferring relationships between closely related species (Chevret et al. 2005). Our studied specimens showed great morphological similarity—in external anatomy, skull and teeth—with *P. williamsi* but were classified as the sister group of the clade *P. williamsi*+ *P. euphratica* in the Bayesian approach.

Habitat selection in the distributional range of the members of the family Dipodidae, have been studied frequently (Shenbrot 1992; Rogovin and Shenbrot 1995; Shenbrot and Rogovin 1995; Hemami et al. 2011; Naderi et al. 2011). Many of these investigations concluded that the habitat selection of these rodents relies mainly on the vegetation cover, climate, and elevation of their environment (Colak and Yiğit 1998; Yiğit et al. 2003). *Parallactaga williamsi* like other jerboas prefer areas that facilitate faster bipedal locomotion, and better entrance to the burrow, so it avoids dense vegetation cover and selects more barren areas while providing it with sufficient food items (Shenbrot and Rogovin 1995; Colak and Yiğit 1998; Yiğit et al. 2003; Naderi et al. 2011). Some other studies on its habitat selection have shown that William's Jerboa selects steppes and semi-arid areas of up to 2,500 m above sea level (Ognev 1948), or areas with sparse vegetation (Toyran and Albayrak 2009). Our observation regarding the habitat of William's Jerboa in northeastern Iran is similar to those of the above authors, and similar to for other jerboas, as well.

Concerning the fact that some cranial and dental measurements of these two new reports show some differences with those described before for William's Jerboa, and also due to their status (and robustness value) in Bayesian topology, more field studies are necessary for a definitive identification. Hence, we provisionally classify the specimens as *P.* cf. *williamsi* in this paper, until more information is available. A comparison of geometric morphometrics, and also molecular analyses will offer a clearer picture on the taxonomic status and the distribution range of this species at the study site.

ACKNOWLEDGEMENTS

This study was partially supported by a grant (no. 3/29121) from Ferdowsi University of Mashhad. KH would like to offer her thanks to A. Hamidi and H. Mozaffari for their help in the field research. Special thank to Dr. G. Shenbrot for his scientific supports and to Dr. V. Malikov for his useful comments.

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Author contributions: KH collected the data and wrote the text. KH and JD made the molecular analysis and MMM financially supported and had valuable discussions about the content.

Received: 5 November 2015
Accepted: 2 March 2016
Academic editor: Guilherme S. T. Garbino